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AN ESSAY ON THE THEORY OF AGRICULTURE,

INTENDED AS AN
INTRODUCTION
TO A
RATIONAL SYSTEM
OF THAT
ART.

> *Atque etiam ſine cauſidicis olim ſatis felices fuere, futuraeque ſunt urbes: at ſine Agricultoribus nec conſiſtere mortales, nec ali poſſe manifeſtum eſt.* COLUMELLA.

BY A FARMER.

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BRITISH MUSEUM

AN ESSAY ON THE THEORY OF AGRICULTURE.

INTRODUCTION.

THE earth, by the antients, was always called Mother; and, with good reaſon, as on her, and in her, are produced all kinds of animals, vegetables, and minerals.

By her productions are they nouriſhed and ſupported; and, on this account, was the epithet, GOOD, added.

Moſt animals, by a ſelf-moving power, can go about in queſt of food, while vegetables, confined to one place, muſt draw their nouriſhment from the ſurrounding materials: the ſame is true with regard to minerals.

Where, then, are placed theſe inexhauſtible ſtores, that, ſince the creation, have ſupported, in an uninterrupted ſucceſſion, the ſeveral tribes?

Animals have daily ſupplies; vegetables are conſtantly nouriſhed; and minerals increaſe.

Animals feed on vegetables; vegetables are nouriſhed by minerals; minerals grow by the addition of particles ſimilar to their ſubſtances, and the neareſt, perhaps, to the chemical principles.

It ſeems highly probable, that the materials, ſubſervient to the ſeveral forms, were furniſhed at the creation, and are to be found in the earth, atmoſphere, or appropriated in the ſubſtances of the ſeveral tribes.

Theſe materials are ſo greatly varied, that it is likely, that at no time ſince the creation were they placed preciſely in the ſame manner, tho' the identical principles are ever employed.

The daily ſupplies of fire we receive from the ſun are of great uſe in actuating the other principles, and ſeem to enter into the compoſition of moſt ſubſtances. By Divine Wiſdom, the ſeveral forms have their proper times of exiſtence appointed them, during which, they draw from the common ſtore of nature whatever is neceſſary to their ſupport; dying, by diſſolution, they return their materials to the inexhauſtible ſtore; and the ſame particles are inceſſantly employed, according to the various chances of nature.

The annihilation of a ſingle particle of matter is altogether inconceivable; the creation of one impoſſible, its being conſtantly employed, is the moſt ſuitable to a wiſe deſign.

Agriculture, by which we vindicate the ſoil from its caſual produce, and ſtock it with trees, grain, &c. &c. for the uſe of man, is my preſent aim, aſſiſted by ſcience, to reduce this to a ſyſtem, to aſſume a few principles evidently exiſting in nature; and by means of which we can underſtand many of her appearances, and that may be able to direct us in particular circumſtances, and to ſecure us from the folly of crediting many things recommended in practice; which, if we follow, diſappointment and regret ſhall prove our only reward.

Boaſted receipts, for increaſing fertility, like quack medicines, however admired, while unknown, are no ſooner diſcover'd and tried, than whatever prejudice attends their firſt appearance, unable to maintain their reputation, they die with contempt, and ought to be buried in oblivion.

The unſullied page of nature, if peruſed with attention and judgment, contains no myſteries; every thing is clear and convincing, and its ableſt commentators have always reduced it to the greateſt ſimplicity.

How deluſive our expectations from many things in practical books, the unhappy circumſtances of their blinded followers too plainly demonſtrate.

A ſingle obſervation in particular circumſtances may prove uſeful; but alter the circumſtances, or apply it univerſally, you deſtroy its uſe.

Authors have labour'd hard in deſcribing ſoils, and have given many marks of rich ſoils, taken from the colour, coheſion of the parts, materials in their compoſition, &c. however oſtentatious, little uſeful.

In general, let me here obſerve, that chemiſtry may contribute more to our knowledge of ſoils, and their productions, by its ſeveral operations, than all the attempts hitherto made by practice and obſervation.

Tull's frequent ploughing of the ſoil greatly increaſed fertility; this he plainly perceived; and, to account for it, had recourſe to the infinite diviſibility of matter; how juſtly, let the impartial reader determine, after peruſing the following ſheets: with what boaſting does he deſpiſe the precepts of the immortal Virgil; and, the better to ſatiate his rage, aſſociates with him all practitioners himſelf excepted.

His merit, as a practical farmer, has been juſtly acknowledged; his theory generally followed; and even his criticiſms approved of.

As to the other practical authors on agriculture, none of them having any regular ſyſtem of theory, I ſhall reſerve the mention of them till I come to the practical part. Dr. Hume has adapted Kulbell's theory in part, has many good things, which I ſhall take notice of occaſionally, as I proceed with the practice.

Whatever reaſonable objections are offer'd againſt this theory, the author will receive with pleaſure, and anſwer with temper; his ſcope was to ſpend a few leiſure hours in inquiring into a ſubject that is as yet far from being exhauſted. Truth he aimed at; and ſhould he find his amuſements of any real uſe, it will agreeably reward him; trifling diſputations, however faſhionable, he has little taſte for; and his moſt ardent wiſhes are to be ſerviceable to mankind.

I ſhall conclude, with obſerving, that thoſe who are well acquainted with chemiſtry, and natural philoſophy, will beſt underſtand my reaſoning; to illuſtrate every thing, by deſcending minutely to particulars, would have proved tedious; and I have endeavoured to render every thing as plain as poſſible in the conciſeſt manner.

CHAP. I.

OF SOIL.

THAT I may be underſtood, I ſhall define, in as brief a manner as poſſible, what is neceſſary, in order that the reader may be able to form a proper judgment of the ſubject: I begin with Soil; it is that part of the ſurface of the terreſtrial globe which is fit for being laboured, and capable of producing vegetables. If this is examined chemically in cloſe veſſels, it yields water, an inflammable ſubſtance; air, ſalt, and earth, ſand and ſtones, are alſo part of moſt ſoils; but as they afford no ſubſtance that can promote vegetation, I ſhall paſs them over, and proceed with my definitions.

CHAP II.

OF WATER.

THIS, ſo neceſſary to vegetation, and the increaſe of all plants, is fluid, without ſmell, taſte, or colour; freezes by cold, and expands itſelf ſtrongly; eaſily evaporates by heat, and is not condenſible; its ſpecific gravity is to gold as 1000 to 19640; the ſmallneſs of its particles are ſuch, as that they have hitherto eluded the ſight, even when aſſiſted by the beſt microſcopes; the deſign of this in nature ſeems to be to render it an effectual ſolvent of every ſaline ſubſtance, and proper vehicle into, and through the ſubſtance of vegetables.

CHAP. III.

OF FIRE.

THE inflammable part is only diſcoverable by our ſenſes when in action, by its ſhining, and rariſying of almoſt all bodies; this I ſhall call fire, whether at reſt, or in action: that it is material, is evident from the increaſe of weight acquired by lead, copper, tin, &c. when expoſed ſometime, either in the focus of a burning-glaſs, or fire from earthly materials: that the rays of light are particles of fire is apparent by their action, as above, and by their force, when reflected from a poliſhed mirror.

CHAP. IV.

OF AIR.

THIS makes a conſiderable part of vegetables, and is abſolutely neceſſary to the life of animals.

Pure air, tho' inviſible, we are certain of its being a fluid, elaſtic, compreſſible, unchangeable, when preſerved in glaſs or metallic veſſels for many years; is conſiderably lighter than the atmoſphere; its ſpecific gravity, compared to water, is as 1 to 606, even to 1000.

It makes the moſt permanent part of the

atmoſphere; and, by its properties, as mentioned, it is fitted for becoming part of almoſt every body in nature, and being a conſiderable agent in the increaſe, as well as diſſolution of bodies.

CHAP. V.

OF SALT.

SALT is a ſubſtance variouſly compounded, yet always capable of being diſſolved in water, when obtained from ſoil by water, and boiled to a pellicle, yields a ſaline ſubſtance, in nothing ſimilar to nitre, neither in conſiſtence, cryſtallization, nor inflammability; it nearlier reſembles ſal ammoniac, which is produced by mixing ſpirit of nitre with an alcaline ſalt obtained from urine or other animal ſubſtances.

CHAP. VI.

OF EARTH.

EARTH, chemically conſidered, is that part of ſoil, or vegetables, which remains after the other parts are ſeparated, in form of a powder, without ſmell or taſte, indiſſolvable in water, ſpirit of wine, or other menſtruums, whether watery or oily; this is copiouſly found in the ſolid parts of animals, vegetables, and minerals.

CHAP. VII.

OF VEGETABLES.

THESE, when ſubjected to chemical inquiries in cloſe veſſels, and expoſed to fire, yield water, an acid ſpirit impregnated with oil, air, volatile ſalt, an empyreumatic oil, and commonly a fixt ſalt by calcination and decoction; and earth remains after the force of fire, and diſſolving power of water, has ſeparated the above. On comparing the productions of this proceſs with what was obtained from ſoil, we ſhall find the water and air the ſame; the fire is evidently in the oil; the earth is altogether the ſame; the acid ſpirit, and alcaline ſalt, when mixed, form neutral or ammoniacal ſalt, greatly reſembling that mentioned chapter fifth.

Our ſenſes ſufficiently aſcertain the ſeveral definitions, and often repeated experiments afford undeniable proofs of the exiſtence of water, air, fire, and earth.

After they have been ſubjected to innumerable chemical trials, they ſtill ſhew both their ſimplicity and unchangeableneſs, and conſequently may, with propriety of language, be called principles; as ſuch I ſhall conſider them for the future, however they may be diſguiſed by their various combinations in ſoil, or vegetables, in the atmoſphere, or under the earth.

No where in nature are the principles to be found pure and unmixed; the pureſt water yields air and earth; air is full of diſſimilar particles; and fire is commonly joined to air and earth: but tho' the above is certainly true, it alters not my reaſoning, nor changes or deſtroys the powers of the principles.

CHAP. VIII.

OF THE ACID SPIRIT.

IN the concluſion of the reaſoning on the laſt proceſs, I found, that two ſubſtances, the acid ſpirit, and alcaline ſalt, attracting each other, formed by their union a compound unlike to either. As the acid ſpirit is firſt produced, I ſhall conſider it, and then proceed to alcali's. That an acid is copiouſly in the atmoſphere, is certainly proved, by expoſing aſhes from wood ſometime to the air, and a ſalt ſimilar to that, chapter fifth, ſhall be generated.

Colcothar of vitriol ſoon recovers from the air the acid ſpirit it loſt by calcination.

Burnt allum, expoſed to the air in clear fair weather, increaſes its weight.

Syrop of violets, mixed with oil of tar-

tar per deliquium, exhibits a green colour, if expoſed ſometime to the air changes to a brown; acid ſpirits, when added, produce the ſame appearance.

Poliſhed ſteel or iron, ruſting, gives unpleaſing proofs of its exiſtence; ſilver, braſs, copper, tin, and lead, are corroded by the ſame.

Were more arguments neceſſary, the excellent Stahl's method of collecting it, may put it beyond doubt. See his Opuſcula, page 117.

By what has been obſerved, it is evident, that it is attracted by the ſubſtances above-mentioned, as it alſo is by ſulphurs, earths, boles, corals, chalks, ſhells of many kinds, alcali's of all kinds, whether volatile or fix'd, inflammable ſubſtances; ſuch as fat of animals, oils, whether from vegetables or animals; joins itſelf readily to water, as may be eaſily obſerved, by expoſing an iron wire bright and free from ruſt to rain; for, by the rain, in a few minutes, its ſurface, will be found corroded by the acid, and ruſted over: this union of water with acid is alſo to be obſerved in the chemical aether.

Moſt of theſe ſubſtances it diſſolves, and many others; pharmacy finds it uſeful in diſſolving gums, earths, boles, corals, metals, &c. is very volatile, as is eaſily proved by the evaporation of acid ſpirits from veſſels unſtopped when expoſed in the open air, and tho' they precipitate in water in diſtilling, yet ſoon riſe through the water, and get into the air as may be ſeen in ſpirit of nitre.

Theſe properties being obſerved, I ſhall for the future call it ſimply acid, tho' it has been denominated by the chemiſts, the univerſal acid, the wandering foſſile acid; and ſome have called it the aetherial ſpirit of the world.

CHAP. IX.

OF ALCALI'S.

THEY are only produced by fire, or putrefaction, whether from vegetable or animal ſubſtances.

Fix'd alcali's, by the addition of water, without any acid, raiſe a conſiderable heat.

They effervеſce with acids, generate air, raiſe a heat, and form neutral ſalts, as chapter fifth.

When joined to an inflammable ſubſtance diſſolve earths, ſome kinds of ſtones, nay metals, are thereby converted into powder,

Precipitate all ſolutions made with acids.

Grow moiſt when expoſed to the air, and at laſt turn liquid.

Do not cryſtallize, unleſs when ſaturated with air.

CHAP. X.

OF THE ATMOSPHERE.

IT is a fluid ſurrounding the earth moſtly compoſed of air, but at the ſame time containing all the other principles formerly defined.

Its weight on the ſurface of the earth is equal to $33\frac{5}{6}$ feet of water; in the moſt depreſſed vallies it is greateſt, and becomes leſs as the aſcent encreaſes.

Its preſſure, that exerts itſelf in all directions, is conſiderably diminiſhed, when the atmoſphere is rarified by heat*, and encreaſed when it is condenſed by cold, or loaded with vapours.

Winds blowing in oppoſite directions accumulate the atmoſphere, and encreaſe its weight. If the direction of the wind is towards the earth, its momentum ſhall encreaſe the preſſure.

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* A gentleman here obſerved, that the barometer contradicts this; but as the perſpiration of plants is greatly encreaſed by heat, and diminiſhed by cold, or moiſtneſs of the atmoſphere, and as the vapours are greatly raiſed by the heat, condenſed and precipitated by the cold, it muſt act on plants, &c. as here mentioned.

If the direction is from the earth, the preſſure muſt be diminiſhed.

CHAP. XI.

OF THE SOLUTION OF BODIES.

I COME now to treat of the natural analyſis, or ſpontaneous diſſolution of bodies.

If a young and juicy vegetable is pulled up, and expoſed to the heat of ſummer or autumn, it ſoon ſhrinks, ſhrivels, becomes dry, and at laſt entirely diſappears; yet this vegetable, if chemically analys'd, would have been found to have contained air, water, fire, earth, ſalt, &c. where now are theſe exhaled particles that lately compoſed the vegetable? not one of them ſhall remain, tho' the expoſure was made on the compacteſt ſurface of China.

I have mentioned the above experiment, as being eaſily made, and ſoon compleated.

If we attend to the action of fermentation in vegetables, and putrefaction in animals, we ſhall obſerve the effect as certain; for tho' animal ſubſtances require more time to diſſolve and diſſipate, yet except a little earth, and fix'd alcaline ſubſtance, all the other principles are elevated, and make part of the atmoſphere.

The moſt durable parts of vegetables, as well as the bones of animals, through length of time, undergo the ſame change; part of them being raiſed into the atmoſphere, and others returning to earth; even glaſs, which carefully kept, ſhall laſt for ages, when expoſed to the ſoil, gradually moulders down, and becomes ſubſervient to vegetable productions.

In what manner the oil contained in, and neutral ſalt formed on theſe ſubſtances, may ſerve to volatilize the earthy parts, will be eaſily underſtood by theſe who are adepts in chemiſtry.

It will conduce to underſtanding the ſubject, to conſider the effect of the ſeveral ſeaſons on the ſoil, atmoſphere, principles mentioned, and vegetable productions. The ſeaſons, then, are the year divided into four nearly equal parts, denominated Winter, Spring, Summer, and Autumn. I ſhall obſerve a few things with regard to theſe in the order of the ſeaſons, as above-mentioned.

CHAP. XII.

OF WINTER.

IN conſidering the ſeaſons, I ſhall begin with viewing the fields at a time when almoſt all vegetables are ſeemingly in a ſtate of reſt.

The foliage, ſo lately the ornament of the trees, is now fallen, and diſſolving into the principles already mentioned, ſhall furniſh materials for the productions of the enſuing ſeaſons.

Plants, annual or biennial, having perfected their ſeeds, ſuffer the ſame diſſolution, and ſerve the ſame purpoſes; as the preceding ſeaſons raiſed and brought them to perfection, ſo having ſerved their ſeveral ends, the ripening of their ſeeds, and propagation of their ſpecies, the autumnal rains having contributed to their diſſolution, the preſent cold compleats it.

In the rigour of winter, the pores of living vegetables, expoſed to the air, muſt be diminiſhed, their juices leſs active, if moved at all.

The diſſolution and elevation of ſo many now uſeleſs parts of vegetables, mix with the atmoſphere many new principles; the cold condenſes the ſame; and, by means of this, renders them more capable of being attracted by the ſoil, now more expoſed by the removal of the crop, and denſer from the prevailing cold; the alcaline ſalts, produced by putrefaction, whether volatile or fixt, become proper receptacles for the univerſal acid; and, by uniting, form the neutral ſalt, chapter fifth: by its union with the volatile ſalt, it is ſoon precipitated, and after being formed with the fixed, it is eaſily diſſolved by the moiſture of the atmoſphere, or falling rains, and mixes with the ſoil.

I have already obſerved, that almoſt all the parts of animals, as well as vegetables, are raiſed into the atmoſphere, that they muſt again become part of the ſoil, is evident from its increaſed fertility; for conſtant obſervation convinces us, that ſoils are rendered unfertile by producing vegetables: what is taken from ſoils by crops, is evident by the chemical analyſis of the crops, and the regaining like principles reſtores fertility; this we find to be the caſe, by ſoils being expoſed to the influences of the atmoſphere for ſome time.

Winter ſeems to be the fitteſt ſeaſon for reſtoring fertility, from the following reaſons:

Firſt, The denſity of the atmoſphere, and the greater plenty of vegetable principles contained in it, from the lately diſſolved vegetables.

Second, The cold condenſing, the ſeveral principles muſt greatly promote their mutual attraction, and conſequently their combining together.

Third, The effect of the froſt on the ſoil opening it to a conſiderable depth, and giving acceſs to the atmoſphere.

Fourth, Impetuous winds impelling the atmoſphere, in different directions againſt the ſoil, muſt greatly promote the attraction, while the ſucceſſive motion muſt bring more of the particles into contact with the ſoil, by frequent change of place.

This is proved by fold-dykes, where the crops that grow on them, after they are thrown down, is always better than on the other parts of the fold that are richly dunged.

Fifth, The moiſture in the atmoſphere diſſolves the ſalts formed in it, and the deſcending rains carry them into the ſoil; froze up with vapours, they deſcend in hail; and ſnow, by the concurring teſtimony of able obſervators, contains great quantities of nitre.

Theſe having entered the ſoil to a conſiderable depth, are detained and mixed intimately by means of the copious moiſture, while the incumbent weight of the atmoſphere, and prevailing colds, prevent their exhaling; the frequent changes, from froſt to freſh, alter the poſition of the parts of the ſoil, and render it more penetrable to the principles formerly mentioned, whether ſimple or combined; thus varying the ſituation will give ſcope to the powers of attraction and coheſion conſtantly acting, as well in the atmoſphere as ſoil, and the produce ſhall be as various as the cauſes.

That fire is now more copious and denſe in the atmoſphere, is ſufficiently ſhewn, by the burning of fire moſt obſervable in pure froſt, when the humid particles are frozen and precipitated.

The ſun-beams paſſing obliquely through the denſe atmoſphere, muſt be greatly accelerated in their courſe, bended to the ſurface of the earth, and impelled with force, which muſt greatly promote their uniting and cohering with the ſoil.

The air, that makes ſo conſiderable a part of vegetables, is now more compreſſed by the cold and weight of the atmoſphere, and conſequently muſt be more powerfully attracted by the parts of the ſoil, and other principles, eaſier combined, and cohere more intimately.

The aether, if poſſeſſed of the properties generally aſcribed to it, ſhall be affected as the air, and the conſequences ſimilar.

From what is obſerved, I may ſafely conclude, that winter, ſeemingly deſolating to the inattentive, is happily employed in repleniſhing the ſoil with vegetable principles needful to the productions of the following ſeaſons.

CHAP. XIII.

OF SPRING.

THE active ſun-beams, now agitating the fire diffuſed through nature, diſpel the cold; the increaſed warmth of the atmoſphere attends the advancing ſeaſon, while the crumbling ſoil confeſſes its fertility, and invites to ſowing; the ſeeds may now ſafely be truſted to the earth.

Seeds, when beginning to vegetate, become ſofter by the increaſe of moiſture, enlarge their ſize, and ſend forth roots, which gradually extending themſelves, their increaſed ſurface imbibes more nouriſhment from the ſoil; this ſoftens and relaxes the parts of the gem, increaſes its bulk, protrudes the foliage, and extends the ſtem. How wiſe the proviſion of nature in many? the covering of the ſeed, matured by the heats of the former ſummer and autumn, proves a defence to the contained plant, not only againſt the ſeverity of the winter, but likewiſe ſecures it againſt the inclemency of ſpring, till the further advance of the ſeaſon favours its appearance, and promotes its increaſe. The lobes in ſeveral ſeedlings, denſer in their ſtructure, and abler to reſiſt injuries, ſerve the ſame purpoſe with the leaves, not only promoting perſpiration, but imbibing from the atmoſphere plenty of moiſture containing many principles proper for promoting vegetation; theſe uſes they ſerve till the expanded foliage ſupply their defect; for, as the leaves advance, the lobes gradually decay, and at laſt diſappear.

All vegetables, the nearer to their origin, contain the greater quantity of moiſture, or have more of water in their compoſition than of the other principles; by means of this they are rendered more ductile, or, in other words, are eaſier extended, and grow faſter; water is certainly the vehicle of moſt of the other principles, and by the exceeding ſmallneſs of its parts is fitted for paſſing through the ſmalleſt veſſels.

For it is highly probable, that vegetables as well as animals, even in embryo, contain all the veſſels of an adult ſtate, nay, many more, and in this caſe how exceeding ſmall muſt the veſſels be?

As the heat encreaſes gradually with the advancing ſeaſon, (Hales puts it from 10 to 20 degrees, St. vol. i. p. 60.) the motion of the ſap becomes quicker, the perſpiration greater, from the increaſe of ſap paſſing through the veſſels they are more extended, and better nouriſhed.

Theſe are evidently diſcernible in vegetables; nor is it unreaſonable to conclude, that the ſeveral principles in the ſoil, by the greater degree of heat, are acted on to a conſiderable depth, more intimately blended, and rendered capable of entering the ſmalleſt veſſels of the roots.

Happy for us in this cold climate, ſubjected to ſuch changes of weather, that the heat of the ſoil is little affected by the cold of the atmoſphere.

The entry of the ſap into the pores of the roots muſt be greatly promoted by the perſpiration; for if we conſider that the veſſels are full from the extremity of the leaſt fibre of the roots, to the ſurfaces of all the leaves and the ſtem, the action of the atmoſphere on the ſurfaces, in carrying of the ſap, muſt promote its entry into the pores of the roots.

If to this is added the wiſe contrivance of nature, in copiouſly ſtoring all vegetables with air veſſels, through the whole of their ſtructure, as well as theſe deſtined to carry the ſap; if the poſition of thoſe with regard to the ſap veſſels is carefully conſidered, and the elaſticity of the included air attended to, we ſhall eaſily be able to conceive, how the heat of the day, dilating the included air, muſt compreſs the ſap veſſels, diminiſh their cavity, and conſequently increaſe their powers of attraction; and how the coldneſs of the night, condenſing the air, muſt dilate the ſap veſſels, and by this promote the entry of the dew on the ſurface of the leaves and ſtem, &c. and that the quantity thus imbibed, c. p. ſhall be in the direct ratio of the condenſation of the air. Theſe cauſes muſt have a greater and greater effect from the increaſe of heat attending the advances of the ſeaſon: in ſpring, when the young plants from ſeeds are full of juice, the flowers and foliage newly expanded, the puſhing ſhoots only extending, and yet delicate, the moderate heat encourages their growth, and promotes their increaſe, without endangering their ſtructure: at this time, ſhould the powerful heat of ſummer prevail, they would ſoon ſhrink and die; or if froſt prevails in the night or morning, the chearing ſun-beams of the following day deſtroy its power, and preſerve the tender plants. By the gradual lengthening of the day, the ſun-beams actuate every principle more and more, heat the atmoſphere and ſoil, baniſh the froſt, evaporate the moiſture that copiouſly deſcends again in frequent ſhowers, encourage the growth of plants, and increaſing their vigour, fits them for bearing the approaching heats of ſummer.

CHAP. XIV.

OF SUMMER.

THE effects of winter, in fertilizing of the ſoil, and of the ſpring in the production of vegetables is now apparent, the ſoil is cover'd with plants, the trees with foliage and fruit.

The increaſed perſpiring ſurfaces, acted on by the heat from 17 to 30 degrees, Hales, vol. i. p. 59. evaporate greater quantities of moiſture through the day; the coolneſs of the evening condenſes the ſame, and precipitates it in dew; how copious this, may be judged of by the pearl-like appearances, viewed ſoon after the riſing of the ſun.

The now prevailing heat, acting on the variouſly combined principles, whether in the ſoil or atmoſphere, unites them more intimately with the water, and renders them more capable of entering the porous roots, or being imbibed by the inſpiring orifices of the expanded ſurfaces, rendered now more patent from the ſultry heat, and great perſpiration; the growth, firmneſs, and ſolidity of vegetables is a proof of earth more abounding in their compoſitions.

For tho' I have defined earth as indiſſolveable in water; yet we are ſure, that when combined with the other principles, its parts are rendered ſo ſmall, as not only to enter the pores of the roots, but to be able to pervade the ſmalleſt canals, whether longitudinal or tranſverſe; the chemical analyſis of any part of the plant will put this out of doubt.

Thus, corns produced, nouriſhed, and brought to ſtrength, are fitted for protruding their flowers, and expanding their ſeveral parts; the apices, or little duſt balls abounding with ſulphur, attract ſtrongly the ſun-beams, and form a ſubtil penetrating powder, eaſily volatilized, and fitted by nature for entering the womb of the plant, and impregnating the ſeed.

Several circumſtances now greatly favour this; the intenſeneſs and duration of the heat through the day, opens not only the apparent entry to the womb, but the exceſſive perſpiration from the parts of the piſtil, and other parts of the germ, diſpoſes them for imbibing ſtrongly the ſubtil effluvia of this impregnating powder, copiouſly diſperſed over the ſurface, and eaſily diſſolved by the dew; the calmneſs and ſerenity of the ſeaſon may greatly contribute to this important act in corns, while cold or cloudy weather, exceſſive rains, or ſtrong winds, muſt not only retard the progreſs, but render many of the grains abortive, by carrying off the powder, or hindering its entrance into the womb or germ.

The buſineſs of ſummer, in increaſing the ſtalk, blowing the flowers, and impregnating the grains, being now compleated, autumn has only to fill the grains, and bring them to ripeneſs.

CHAP. XV.

OF AUTUMN.

THE heat now arrived at its higheſt degree, (50 degrees, Hales, vol. i. p. 59.) more intimately unites the fiery and aerial particles, that ſtrongly attract each other, and form the oil, which makes ſo conſiderable a part of ſeeds, their coverings, fruits, kernels, &c. while the watery and ſaline are raiſed into the atmoſphere, or detained in the ſoil: for the ſtalk, and other parts, being come to greater firmneſs, and their growth compleated, powerfully attracts the ſulphureous and aerial particles, while it repels the ſaline, watery, and acid.

This is evidently the caſe in grains; for, at firſt, their contents are watery, then milky, a certain proof of oil in their compoſition; this gradually thickens (poſſibly by the addition of the particles of light or ſun-beams; for that the principles are capable of entering into ſubſtances, loſing their properties on being compounded, and aſſuming the ſame on being ſeparated from bodies, is obſerved both by natural philoſophers and chemiſts, nay, is obvious in innumerable inſtances) till ripeneſs enſues; which ſeems to be the ſtate of perfection appointed by the wiſe Author of nature.

By conſtant obſervation we ſee, that the ſerener and warmer the weather, the earlier ripeneſs, and the better the grain, which ſeems greatly to ſupport the above conjecture.

This was ſufficiently proved by crop 1757, when a fine warm ſeaſon produced corns uncommonly good, and reſtored plenty after ſeveral years of dearth.

CHAP. XVI.

OF SOILS.

THO' the richneſs or fertility of ſoils muſt in a great meaſure depend on the quantity of neutral ſalt contained in them, yet there are other conditions neceſſary; they muſt not be too ſtiff; or, in other words, muſt not cohere too firmly; by means of this, the influences of the atmoſphere ſhall be prevented, and the roots of plants impeded in their progreſs; whatever water the earth imbibes, ſhall be too long retained, and conſequently the ſoil rendered cold, not eaſily agitated by the ſun-beams, and its productions retarded; in this claſs are tenacious clays; the lower and plainer they lye, the more they are in danger of proving unfertile from the water, and the later muſt their productions be.

To remedy theſe inconveniences, the laying the ground in ridges, with the crown or middle raiſed high, expoſes a greater ſurface to the influences of the amoſphere, the action of the ſun beams, and motion of the winds. By this the fallen rains eaſily run off, the vapours are elevated, the winter froſts penetrate, and open the ſoil, the ſalts diſſolving, diſunite the parts, and enriching the ſoil, renders it more pervious to the roots, to the dews, and ſun-beams. The practice of laying ſand on clays is of little uſe, as they ſeldom mix intimately.

Of the greateſt improvement are ſuch ſubſtances as by their heat evaporate the moiſture; ſuch as form or contain the neutral ſalt, chapter fifth. Amongſt theſe may be reckoned the dung of horſes, cows, hogs, ſheep, poultry, &c. lime, ſoot, aſhes, earth richly impregnated with neutral ſalt, and of which the parts do not cohere, but are free and open.

Summer and winter fallowing, both tend to open clays rich generally in themſelves, and of which the greateſt fault is the coheſion of their parts.

Having mentioned one extreme, I proceed to its oppoſite, the open ſandy ſoil. Here is an eaſy admiſſion to the influences of the atmoſphere; the water eaſily enters, and eaſily evaporates; the extending roots find little reſiſtance in their progreſs; the influences of the ſun are ſoon felt, and continuing their acting without much hinderance from humidity, the productions are earlier; but as the other over-abounds with water, this is often deficient; to remedy which, if placed on a declivity, ploughing acroſs; if on a plain, the laying it flat may prove beneficial.

The beſt additions for enriching ſuch ſoil, are ſuch as are fit for forming the ſalt, chapter fifth, or really contain it. Lime, as it attracts moiſture copiouſly from the atmoſphere, ſoot, aſhes, marles, cow-dung, if laid on in the autumn or beginning of winter, reſting and paſturing. Here the productions naturally incline us to believe, either that the univerſal acid more abounds in the ſoil, or eaſier enters the productions, as the ſorrels and other plants, whoſe juices are acid, are here found in plenty, while the alcaleſcent plants are natives of the low and moiſt ground.

The obſervations made above, may be eaſily applied to all the intermediate degrees of ſoil, and the following obſervations eaſily underſtood; why in ſoils, where moiſture over-abounds, the corns make leſs progreſs in the ſpring and beginning of ſummer, and advance faſter in the end of ſummer and autumn.

Why corns that grow in the ſhade become taller, but are longer of ripening, and the grains not ſo good as what grows in the open fields; why the grains, when the corns are lodged or laid, loſe one third or thereby, as frequent experience ſufficiently proves.

CHAP. XVII.

OF THE NOURISHMENT OF PLANTS.

TO talk further of the nouriſhment of plants is needleſs, the principles neceſſary to this are beſt diſcovered by the chemical analyſis of the plants. See chapter ſeventh. And tho' theſe principles are variouſly combined in ſoils; yet, allowing a few exceptions, moſt ſoils are capable of bringing corns to perfection; continued crops exhauſt the fertileſt ſoils; what they deprive them of, chemiſtry informs us in analyzing the produce. The common and ſucceſsful methods uſed for reſtoring fertility, are:

1. Reſting with, or without graſſing.

2. Fallowing, by which the ſoil is not allowed to loſe any thing, by producing vegetables, and is expoſed to the influences of the atmoſphere.

3. By dung, lime, aſhes, &c. which we are certain contain earth, alcalies, fire, &c. I ſhall conſider each of theſe in the order as above.

CHAP. XVIII.

OF RESTING AND PASTURING.

WE commonly obſerve the firſt year's graſs thinner, and the produce leſs, by the cattles frequent croping of the graſs, the herbs tiller, or grow thicker; the ſecond year's graſs being much better, is a proof of the number of plants being increaſed, and the ſoil becoming more fertile; the third, and ſubſequent years, encreaſes gradually the plenteouſneſs of the graſs, and fertility of the ſoil. The greater the number of the cattle, in proportion to the extent of the paſture, if the cattle are ſufficiently graſſed, the more ſhall the ſoil be enriched, and the ſooner fitted for producing large crops of corns: if a ſtone is fixed in the ſoil, with ſome part of it raiſed above the ſurface, we may obſerve the encreaſing of the ſoil, from the gradual covering of the eminent part of the ſtone.

When the herbage is permitted to grow

up, come to perfection, fall down, and rot on the ground, we perceive the ſoil encreaſes faſt, and ſoon becomes fertile.

If the herbs are cut down, and carried off, as when we make hay, the increaſe of ſoil ſhall be leſs, and the increaſe of fertility inconſiderable, if any thing at all; certain we are, that after the ſecond or third ſummer, the crops of hay diminiſh ſo conſiderably, that in a few years the field becomes only fit for paſture.

CHAP. XIX.

OF FALLOWING.

BY ploughing of ground ſoon after the crop is removed, we expoſe a larger ſurface to the action of the atmoſphere, and conſequently the attraction muſt be greatly promoted betwixt the particles in the ſoil and atmoſphere, and the ſoil ſooner enriched.

It ſeems probable that the parts of the ſoil in contact with the atmoſphere, after having been expoſed ſometime, become ſaturated, or filled with vegetative principles: hence, the neceſſity and uſe of frequent ploughing is apparent; for, by expoſing new ſurfaces, in which the attraction is ſtronger, till ſaturation enſue, we at laſt enrich the ſoil to ſuch a degree, as to render it fit for the production of theſe corns which require the moſt copious nouriſhment, ſuch as wheat, &c.

That this is really the caſe, is evident, from comparing the new ploughed ground in the ſame field with what has been expoſed to the atmoſphere for ſome time; the firſt is firm from the coheſion of its parts; the other is free and open from the inſinuated ſalts.

This may be obſerved of fallowing in general.

Summer fallowing has ſeveral other advantages beſides the above-mentioned; the ſeeds of annuals, many of which ſo pernicious to the crops of our crofts, are encouraged to grow, and being ploughed down before perfecting their ſeeds, can never trouble us more; the roots of perennials, by being often turned up, are alſo deſtroyed, and the ſubſtance of both contribute to enrich our grounds.

From the openneſs of the ſoil, the atmoſphere, the water, whether it falls in rain, or deſcends in dew, the ſun beams all pervade it to a conſiderable depth, and their influence may be eaſily underſtood, from what is formerly obſerved.

CHAP. XX.

OF DUNGS.

THEY are that part of the food of animals, which paſſes after their ſtomachs and guts have extracted the part neceſſary for their nouriſhment.

It is generally putrifying, when excluded from horſes and ſome other animals; and, if kept in a heap, this action is continued; and, by the particles ſtrongly repelling each other, attended with great heat, which expanding the included air, it regains its elaſticity, and carries along with it into the atmoſphere many of the other principles, as the ſmell ſufficiently proves.

The greater part of what remains after the putrifaction is compleated, ſeems to be earth, and a fixt alcali, both ſtrong attractors of the univerſal acid, and conſequently proper for the production of ſalt, chapter fifth. In the dung of cows a neutral ſalt ſeems to be formed in their bowels, and ſo excluded.

When cow dung is expoſed to the air, it attracts and retains a great many fiery particles, as the burning, after it is dry, ſufficiently proves.

A little attention to the food of animals, and the nouriſhment they require, will inform us of the nature of the dung, and its fitneſs for the different ſoils. If grains of the meally kind, given entire, they paſs little changed as to their external appearances, and are only deprived of ſome of their oilly and ſaline parts.

If ſtraw or hay is the food of the animal, the dung ſhall be more copious, tho' leſs valuable.

Beſides the excrements of animals, every part of their bodies contains a ſubſtance that greatly contributes to enrich the ſoil: this experience ſufficiently proves, by the uſe of ſhavings of horns, hooves, hair, &c. but if any one doubts this, take any dead animal, and lay it to rot on the ſurface of a field that is to be in corn the enſuing year, and the luxuriancy of the growing corn will point out the place where the putrifaction was compleated, any time through the following ſummer or harveſt: and yet it is certain, that putrid animal ſubſtances cannot promote vegetation, till the ſalt I have mentioned is formed, from the remaining alcaline and earthy ſubſtance joined to the univerſal acid, &c. Several farmers put ſo high a value on the urine of cows, that, at conſiderable expence, they make proper receptacles behind their ſtalls, into which they put earth, and let it remain till it is thoroughly filled with urine, then they remove it, and put new earth in its place, and ſo continue this practice thro' the year, by which they amaſs a conſiderable quantity: this they employ as dung; but if the coſt is reckoned, and the produce fairly ſtated from the crops, the practice will be found to be attended with ſmall profit, whatever gain the farmer propoſed. Even rags, that for the moſt part contain animal effluvia, are purchaſed for money, and employed to good account by the farmer. But it is not my deſign at preſent to conſider or treat of the practice in farming; that I leave to another occaſion, only permit me here to mention, that the theory I have endeavoured to eſtabliſh, if well underſtood, will ſerve to guide my brethren, in judging of the goodneſs and uſes of the ſeveral dungs, and will put them on their guard againſt truſting the dealers in eſſences of dungs, and the pretenders to infallible ſecrets for procuring incredible fertility; the intelligent will ſee, at once, that

Nature has fix'd bounds to fertility beyond which we cannot proceed, however prompted by avarice, or ſeduced by hopes: but when ſound reaſon directs the farmer, the reward of his labour is ſure, and the return for his expence certain.

C H A P. XXI.

OF LIME.

THE manner of trying lime-ſtone, by pouring on of vinegar, or any other acid, and its fermenting with this, gives us ſome knowledge of the nature of its ſubſtance; tho' the burning alters the texture of its parts ſo conſiderably, as not to leave the leaſt reſemblance to what it was before; yet this property we find greatly encreaſed. The ſalt formed, by pouring on of acids, is of a neutral kind, perſiſts in a liquid ſtate, and diſſolves many ſubſtances, fatty, ſulphureous, earthy, &c. No matter whether the lime is produced from ſtone or ſhells, &c. it ſhall be found to conſiſt of a fix'd or earthy ſubſtance, a volatile air, and a great deal of an inflammable ſubſtance: how fit theſe are for promoting vegetation, may be eaſily enough underſtood from what is obſerved.

For the effect of aſhes in fertilizing of ſoil, ſee chapter ninth.

CHAP. XXII.

OF MARLES.

THEIR ſwelling and falling in water, fermenting with acids, and falling aſunder when expoſed to the air, are no inconſiderable proofs of an alcaline ſalt in their compoſition.

Theſe marles that are copiouſly found below moſs, gives reaſon to believe, that they are formed in the following manner; as there are great quantities of rotten wood in moſs, the heat of ſummer evaporating the moiſture, forms the alcaline ſalt, which is known greatly to abound in rotten wood, the water in autumn and winter diſſolves them; but, by continuing long in the water, whatever acid it has attracted from the atmoſphere through the ſummer quits it, and evaporates; the ſalt precipitates through the ſoft ſubſtance of the moſs, and ſo is collected at bottom: nor is it to be wondered at, that ſuch quantities ſhould be found, the ſame proceſs having been annually repeated for centuries, nay in ſome moſſes perhaps for thouſands of years.

But as there are many marles of very different kinds, as their colour, conſiſtence, and ſubſtance, ſufficiently ſhow; and moſt of them of conſiderable uſe, in rendering ſoils more fruitful: by attending to the different ſubſtances placed above the marle pits, and in the neighbourhood, we may perhaps be able to gueſs at the manner of their formation, and the nature of their ſubſtance. It will alſo be of ſome uſe to expoſe them to the atmoſphere; and from time to time obſerve the effects of its influence, as likewiſe to obſerve what power water exerts in their diſſolution, or otherwiſe, when applied in different manners, as a menſtruum. But to ſuch as are able, I would recommend it to inveſtigate them chemically, in order to diſcover the quantity of the ſeveral principles, of which they are compoſed, and the manner in which they are combined; as by experiments he may at laſt be able to underſtand the reaſon, why ſome marles produce plenteous crops ſoon after being laid on the ſoil, and are exhauſted in a few years; while others continue their fertility, and produce crops for many years. But, in order to profit by theſe trials, let a farm-book be carefully kept, and the expence and profit of every year marked down, that he may be enabled to judge of what returns may reaſonably be expected from the uſe of each kind.

CHAP. XXIII.

OF HEAT.

HEAT is a ſenſation with which every one is well enough acquainted; it ſeems to be owing to the motion of the particles of fire diffuſed through all bodies.

Evident cauſes of this motion, are firſt the ſun-beams; they actuate the particles of fire in the atmoſphere, the ſoil, and every pervious body whatever.

The rarer the bodies, the eaſier are the fiery particles put in motion, and the ſooner do they return to a ſtate of reſt; or, in other words they ſooner loſe their heat.

The denſer bodies are longer of being heated, acquire a greater degree of heat, and retain it longer.

The ſecond cauſe is putrifaction, where the fiery particles are put in motion by the particles of the putrifying bodies ſtrongly repelling each other.

The third is actual fire, where the particles are greatly agitated, and brought into ignition, or what we call flame; but, as the force of this, undiminiſh'd, certainly deſtroys all vegetables, I have only mentioned it on the account of its uſe in promoting vegetation, when applied under proper regulations in ſtoves, flews, &c.

That the various productions of vegetables in the different climates, is owing to the degree of heat prevailing in them, we are pretty well aſſured from our own experience; for, by applying heat, and regulating it properly, we enjoy almoſt all the vegetable productions of climes warmer than our own.

CHAP. XXIV.

OF COLD.

HAVING mentioned the moſt obvious cauſes of heat, and its univerſal influence on vegetation, I ſhall next conſider the cauſes which hinder its acting, and prevent its effects; the firſt is cold, which, altho' we are altogether unacquainted with the nature of its particles, yet we are as ſenſible of its effects as of the effects of heat: its degrees are aſcertained by the thermometer, and when it approaches near the freezing point, or goes below this, it retards vegetation in moſt plants.

The ſecond is water or moiſture, which, if too copious in the ſoil, prevents the uſeful influences of both the ſun-beams and putrifaction, diminiſhes the heat, or, in the vulgar expreſſion, chills the ſoil.

Water eaſily admits the particles of cold, and by them becomes a ſolid body; but tho' theſe are not admitted, ſo as to occaſion freezing, yet they muſt hinder the action of water as a ſolvent, or menſtruum.

CONCLUSION.

LET it now ſuffice to have obſerved ſome of the general appearances in nature. Were I to purſue her through the vaſt variety of her productions, and conſider each of them ſingly; were I to mark the ſenſible differences in things moſt ſimilar, how great the task? how endleſs the labour? how few the principles? Earth, Water, Fire, and Air, include the whole; yet how various the combinations? how numerous the productions? Animals, vegetables, and minerals, are made up of no other; and notwithſtanding how different their forms? how diverſified their natures? the evident cauſes are heat and cold, oppoſite in their nature and effects, yet alternately acting in their ſeveral ſeaſons; ſince the creation, they have unerringly ruled the varied year, that never once failed in its productions. Blind, indeed, muſt the man be, who does not ſee deſign and contrivance in every part of nature, and ſtupidly inattentive, who believes every thing the reſult of chance: and tho' after the moſt ingenious and ſucceſsful inquiries, many things exceed the ken of mortals; yet ſufficient is known to convince any reaſonable man of the wiſdom, power, and goodneſs of the Author of nature.

FINIS.

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